REMARKS

Claims 47 and 48 along with newly added claims 76-79 are currently pending in the present patent application. In an Office Action mailed December 5, 2001, the Examiner rejected all claims, but the basis for each rejection is unclear. First, it appears the Examiner rejected claim 47 under 35 U.S.C. § 103(a) since the rejection is set forth under the "Claim Rejections-35 USC § 103" section of the Office Action. When discussing claim 47, however, the Examiner indicates the claim was rejected under 35 U.S.C. § 102(e) as being anticipated by U.S. Patent No. 6,136,690 to Li ("Li"). The undersigned is unclear as to the basis of the rejection of claim 47. Both grounds of rejection will be discussed below when discussing claim 47.

Regarding the rejection of claim 48, this claim was rejected under Section 103(a) as being unpatentable over a reference to Schulz *et al.* ("Schulz") in view of an IBM Tech. Discl. Bull. Vol. 33, No. 11, p. 352 ("IBM"). This rejection is similarly somewhat confusing in that the Schulz and IBM references are applied only against claim 48 even though this claim depends ultimately from claim 45, with each intervening claim being rejected over a unique reference or pair of references. Regardless, the rejection of claim 48 over Schulz and IBM will be discussed in detail below.

In order to help the Examiner appreciate certain distinctions between the pending claims and the subject matter of the applied references, the disclosed embodiment of the invention will now be discussed in comparison to the applied references. Specific distinctions between the pending claims and the applied references will be discussed after the discussion of the disclosed embodiment and the applied references. This discussion of the differences between the disclosed embodiment and applied references does not define the scope or interpretation of any of the claims.

Applicant's invention exposes a conductive layer to an oxygen-inhibiting plasma or other gas, including nitrogen free gases, prior to the formation of the another layer or layers on the conductive layer to substantially reduce the association of oxygen with the conductive layer during formation of the other layer or layers. By reducing the amount of oxygen associated with the conductive layer, the electrical characteristics of a semiconductor device including the conductive layer are improved, as will be discussed in more detail below with reference to the

disclosed embodiments of the invention. One embodiment of the present invention is discussed with reference to Figures 7-10 in which an interposing layer 52 such as a tungsten nitride layer 52 is formed between a conductive plug 46 formed in a via 44 and a conductive line material 48 formed in a trench or container 50. The tungsten nitride layer 52 enhances the electrical contact between the line material 48 and the plug 46, promotes adhesion of the line material within the container 50, and prevents or slows the diffusion of materials across the tungsten nitride layer boundary, or serves some other purpose. The tungsten nitride layer 52 may associate with oxygen after it is formed and subsequent thermal processes may result in the formation of an oxide layer 54 formed between the tungsten nitride layer 52 and the line material 48 as shown in Figure 8. Because the oxide layer 54 is an insulator, this layer will adversely affect the electrical connection between the line material 48 and the plug 46.

By exposing the tungsten nitride layer 52 to an oxygen-inhibiting agent or a reducing atmosphere prior to formation of the line material 48, the thickness of the oxide layer 54 is reduced to a thickness of less than 10 angstroms or entirely eliminated as illustrated respectively in Figures 9 and 10. As described in the specification, the tungsten nitride layer 52 or other conductive layer may be treated with gases such as diborane B_2H_6, PH_3, CH_3SiH_3, $(CH_3)_3Si\text{-}Si(CH_3)$, HMDS, CF_4, CHF_3, HCL, BCl_3, and silane SiH_4, and any combinations of these gases, as described on page 7, lines25-30, page 8, lines 1-16, and page 9, lines 1-12. Even if the tungsten nitride layer 52 is exposed to oxygen, the layer may thereafter be exposed to a reducing atmosphere, such as silane gas SiH_4, prior to formation of the line material 48 to thereby reduce the oxygen content of the tungsten nitride layer 52 and reduce the thickness of or eliminate any silicon dioxide layer 54 thereafter formed. A reducing atmosphere removes oxygen from a material, which is said to have been reduced, in contrast to oxidation in which a material associates with oxygen, as understood by those skilled in the art.

The Li patent discloses de-oxidizing method for removing oxygen from a surface onto which a refractory metal is to be formed. Referring to Figure 1e, a gate oxide 159 is formed on a substrate and a polysilicon layer 161 formed thereon. A titanium nitride layer 162 is formed on the polysilicon layer 161 and a tungsten layer 163 formed on the titanium nitride layer. Li discloses a plasma treatment of the titanium nitride layer 162 prior to formation of the tungsten layer 163 to remove oxygen from the titanium nitride layer. In Li, silane is used in the formation

of a the tungsten layer 163 as described in column 8, lines 16-35, and is not used as part of a reducing atmosphere to remove oxygen from the titanium nitride layer 162. No discussion in Li suggests or teaches using silane to reduce the titanium nitride layer 162 in combination with a plasma treatment.

Schulz is directed to the deposition of tungsten on titanium nitride and discloses an HF and NF3 plasma treatment of the titanium nitride. The mention of silane in Schulz is, once again, with reference to formation of the tungsten layer and is not used in the reduction of the titanium nitride. The IBM reference discloses treatment of gold-based ohmic contact on GaAs, which occurs due to native oxides and excess As at a dielectric-GaAs interface. The treatment includes of the GaAs with an H2 and N2 plasma prior to dielectric deposition to remove any residual oxides and excess As and is performed after a wet etch of the GaAs to remove native ozides. Another process includes treatment in an H2 plasma then depositing a thin silicon layer on the GaAs to prevent surface oxidation prior to dielectric deposition. Once again, silane is not used in the IBM reference in a reducing atmosphere to remove oxides, but is instead used to form an silicon layer to passivate the surface and prevent the formation of oxides on the surface. Thus, even when combined, the Schulz and references do not teach or suggest treating a surface with an N2/H2 plasma and exposing the surface to a reducing atmosphere such as silane.

Returning now to the claim rejections, amended claim 47 has been rewritten in independent form. Amended claim 47 recites a method of treating a wafer including depositing a first conductive layer onto the wafer, exposing the wafer in situ to a reducing environment, depositing a second conductive layer, and exposing the wafer in situ to an N2/H2 plasma prior to depositing the second conductive layer. If Li is applied as prior art under Section 102(e), Li fails to disclose depositing a first conductive layer onto a wafer and exposing the wafer in situ to a reducing environment, and also exposing the wafer in situ to an N2/H2 plasma prior to a second conductive layer being formed on the first conductive layer. Thus, even if Li is applied against claim 47 under Section 102(e), the combination of elements recited in claim 47 is allowable.

Regarding the rejection of claim 47 under Section 103 in view of Li, under Section 103(c) "[s]ubject matter developed by another person, which qualifies as prior art only

under one or more of subsections (e), (f), and (g) of section 102 of this title, shall not preclude patentability under this section where the subject matter and the claimed invention were, at the time the invention was made, owned by the same person or subject to an obligation of assignment to the same person." The Li patent qualifies as prior art only under subsections (e), (f), and (g). The undersigned states as follows regarding the common ownership of the Li patent and the invention covered by the present patent application:

Statement Regarding Common Ownership

The Li patent and the invention covered by the present patent application were, at the time the invention covered by the present application was made, subject to an obligation of assignment to Micron Technology, Inc., which is the assignee of the present application and the Li patent.

Accordingly, the Li patent may not be applied as prior art under Section 103 against any of the claims of the present application. *See* MPEP § 706.02(l)(1)-(2).

New claim 76 recites a method of treating a wafer including depositing a first conductive layer onto the wafer, exposing the wafer in situ to a reducing environment, depositing a second conductive layer, and exposing the wafer to a selection consisting of diborane, phosphine, methylsilane, hexamethyldisilane, hexamethyldisilazane, HCL, boron trichloride, and combinations thereof. None of the Li, Schulz, nor IBM references, nor any of the other references of record, disclose or suggest exposing a wafer having a first conductive layer thereon to a reducing atmosphere and to a selection consisting of diborane, phosphine, methylsilane, hexamethyldisilane, hexamethyldisilazane, HCL, boron trichloride, and combinations thereof. The combination of elements recited in new claim 76 is therefore allowable.

The claims dependent on the independent claims are allowable for the same reasons as the independent claims, and because of the additional limitations added by the dependent claims.

All pending claims are in condition for allowance, and favorable consideration and a Notice of Allowance are respectfully requested. The Examiner is requested to contact the

undersigned at the number listed below for a telephone interview if, upon consideration of this amendment, the Examiner determines any pending claims are not in condition for allowance.

Attached hereto is a marked-up version of the changes made to the claims by the current amendment. The attached page is captioned "**Version with Markings to Show Changes Made**".

Respectfully submitted,

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Enclosures:
Postcard
Fee Transmittal Sheet (+ copy)
Supplemental Information Disclosure Statement
Form PTO-1449 with Cited References (5)

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VERSION WITH MARKINGS TO SHOW CHANGES MADE

In the Claims:

Claims 45 and 46 have been cancelled.

Claims 47 and 48 have been amended as follows:

47. (Amended) A method of treating a wafer, comprising:

depositing a first conductive layer onto the wafer;

exposing the wafer in situ to a reducing environment; and

depositing a second conductive layer; and [The method in claim 46, further comprising step of]

exposing said wafer in situ to an N2/H2 plasma prior to said step of depositing a second conductive layer.

48. (Amended) The method in claim 47, wherein exposing the wafer in situ to a reducing environment comprises exposing the wafer to silane gas and wherein said step of exposing said wafer in situ to an N2/H2 plasma comprises exposing said wafer in situ to said N2/H2 plasma prior to said step of exposing said wafer to silane gas.